

UNANNOUNCED

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AD-820292

**MECHANICAL-PROPERTY DATA**  
**HP 9Ni-4Co-25C**  
**STEEL**

Tempered Forging

Issued by

Air Force Materials Laboratory  
Research and Technology Division  
Air Force Systems Command  
Wright-Patterson Air Force Base, Ohio

June, 1967

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AF 33(615)-2494

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This data sheet was prepared by Battelle Memorial Institute under Contract AF 33 (615)-2494. The contract was initiated under Project No. 7381, "Materials Application", Task No. 738106, "Design Information Development". The major objectives of this program are to evaluate newly developed structural materials of potential Air Force weapons-system interest and then to provide data-sheet-type presentations of mechanical data. The program was assigned to the Structural Materials Engineering Division at Battelle under the supervision of Mr. Walter S. Hyler. Project engineer was Mr. Omar Deel. The program was administered under the direction of the Air Force Materials Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, by Mr. Marvin Knight, project engineer.

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HP 9-4-25

The HP 9-4-25 alloy is a nickel-cobalt steel possessing excellent toughness when quenched and tempered to yield strength levels up to about 200 ksi. It is especially suitable for highly stressed structures requiring good material reliability and weldability and is intended for fabrication in the heat-treated condition for moderate and heavy section.

This steel is sensitive to thermal-mechanical treatments and both the strength and toughness can be increased by hot-cold working.

HP 9-4-25 is available as sheet, plate, wire, rod, bar, and forgings.

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HP 9-4-25 Data<sup>(a)</sup>

Condition: 1025 F Temper<sup>(b)</sup>

Thickness: 2-1/2 in. Forging

Properties	Temperature, F			
	RT	500	700	900
<u>Tension</u>				
F <sub>tu</sub> (longitudinal), ksi	196	182	167	142
F <sub>tu</sub> (transverse), ksi	194	181	167	141
F <sub>tu</sub> (short transverse), ksi	197	--	--	--
F <sub>ty</sub> (longitudinal), ksi	186	160	145	128
F <sub>ty</sub> (transverse), ksi	185	162	145	125
F <sub>ty</sub> (short transverse), ksi	186	--	--	--
e <sub>t</sub> (longitudinal), percent in 2 in.	19.3	19.8	18.2	19.9
e <sub>t</sub> (transverse), percent in 2 in.	18.2	17.8	18.0	18.5
e <sub>t</sub> (short transverse), percent in 1 in.	17.7	--	--	--
RA (longitudinal), percent	66.2	68.5	71.2	73.3
E <sub>t</sub> (longitudinal), 10 <sup>6</sup> psi	27.8	27.6	26.2	25.6
E <sub>t</sub> (transverse), 10 <sup>6</sup> psi	27.6	26.9	26.3	24.2
<u>Compression</u>				
F <sub>cy</sub> (longitudinal), ksi	196	169	155	131
F <sub>cy</sub> (transverse), ksi	196	168	155	130
E <sub>c</sub> (longitudinal), 10 <sup>6</sup> psi	30.1	27.9	26.1	23.2
E <sub>c</sub> (transverse), 10 <sup>6</sup> psi	30.1	27.8	27.0	23.5
<u>Shear<sup>(c)</sup></u>				
F <sub>su</sub> (longitudinal), ksi	123.6	U <sup>(d)</sup>	U	U
F <sub>su</sub> (transverse), ksi	124.5	U	U	U
<u>Impact (V-notch Charpy), ft-lb</u>				
	35-50 <sup>(a)</sup>	U	U	U
<u>Fracture Toughness, K<sub>IC</sub>, ksi <math>\sqrt{\text{in.}}</math></u>				
	No pop-in <sup>(f)</sup>	U	U	U

Properties	Temperature, F			
	RT	500	700	900
<u>Axial Fatigue (transverse)<sup>(g)</sup></u>				
Unnotched, R = 0.1				
10 <sup>3</sup> cycles, ksi	205	198	194	U
10 <sup>5</sup> cycles, ksi	183	174	172	U
10 <sup>7</sup> cycles, ksi	160	144	120	U
Notched, K <sub>t</sub> = 3.0, R = 0.1				
10 <sup>3</sup> cycles, ksi	195	191	182	U
10 <sup>5</sup> cycles, ksi	83	74	71	U
10 <sup>7</sup> cycles, ksi	60	55	49	U
<u>Creep (transverse)</u>				
0.5% elongation, 100 hr, ksi	NA <sup>(d)</sup>	NA	135	73
0.5% elongation, 1000 hr, ksi	NA	NA	130	62
<u>Stress Rupture (transverse)</u>				
Rupture, 100 hr, ksi	NA	NA	155	95
Rupture, 1000 hr, ksi	NA	NA	148	70
<u>Stress Corrosion</u>				
80% F <sub>ty</sub> , 1000 hr max.	No cracks <sup>(b)</sup>	U	U	U
<u>Coefficient of Thermal Expansion<sup>(i)</sup></u>				
68 to 800 F = 6.4 x 10 <sup>-6</sup> in./in./F				
<u>Density<sup>(i)</sup></u> 0.28 lb./in. <sup>3</sup>				

(a) Data are average of triplicate tests conducted at Battelle under the subject contract unless otherwise specified. Fatigue, creep, and stress-rupture values are from data curves generated using a greater number of tests.

(b) Treatment: 1 hr at 1600 F, AC; 1 hr at 1525 F, OQ; 2+2 hr at 1025 F.

(c) Double shear (1/4-inch pin).

(d) U, unavailable; NA, not applicable.

(e) Values from Reference (1).

(f) Fatigue-cracked single-edge-notched slow-bend specimen (1" x 2" x 18") tested under four-point loading. No pop-in detected.

(g) "R" represents algebraic ratio of the minimum stress to the maximum stress in one cycle; that is,  $R = S_{min} / S_{max}$ . "K<sub>t</sub>" represents the Neuber-Peterson theoretical stress-concentration factor.

(h) Alternate immersion, 3-1/2% NaCl. Three-point loading bend test.

(i) Values from Reference (2).

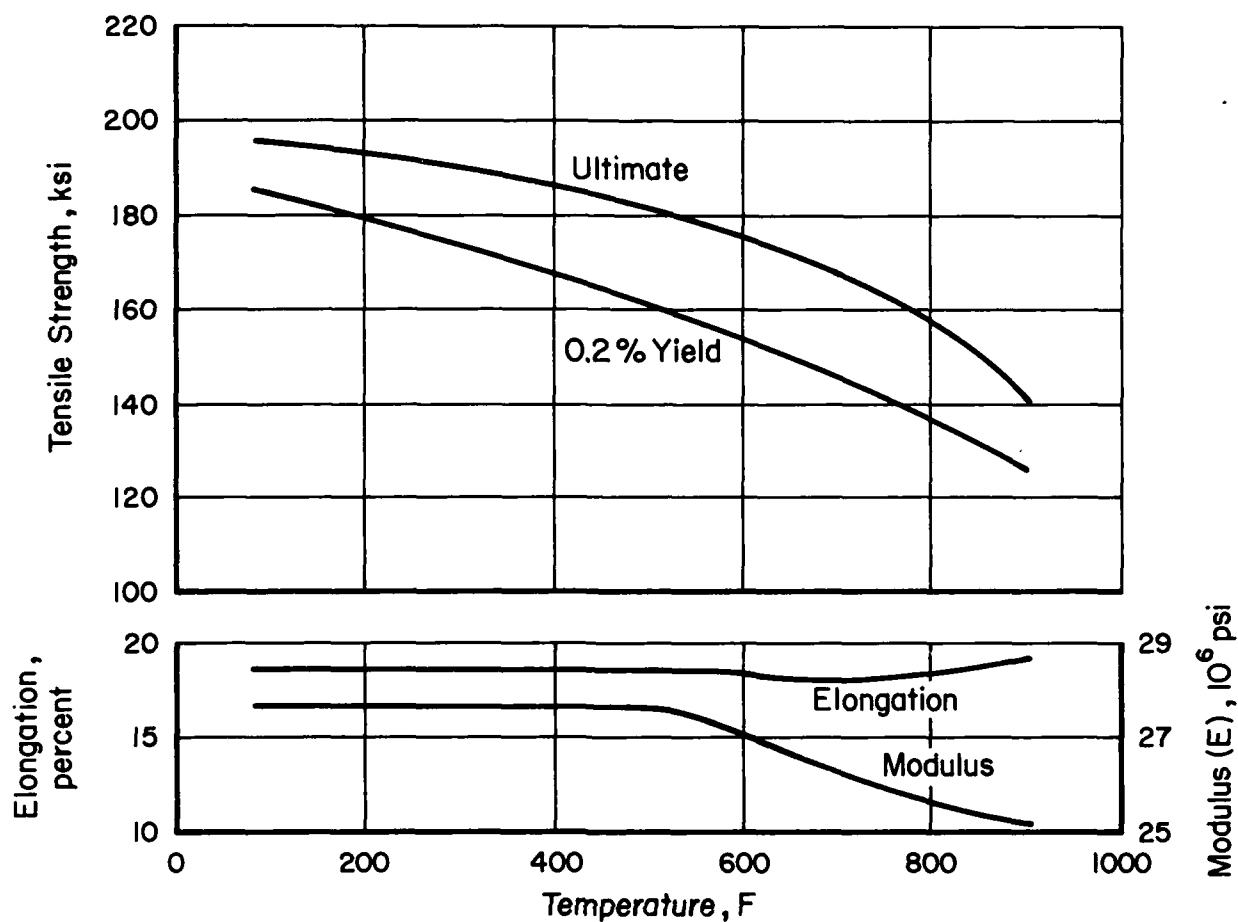


FIGURE 1. EFFECT OF TEMPERATURE ON THE TENSILE PROPERTIES OF HP 9-4-25 FORGINGS

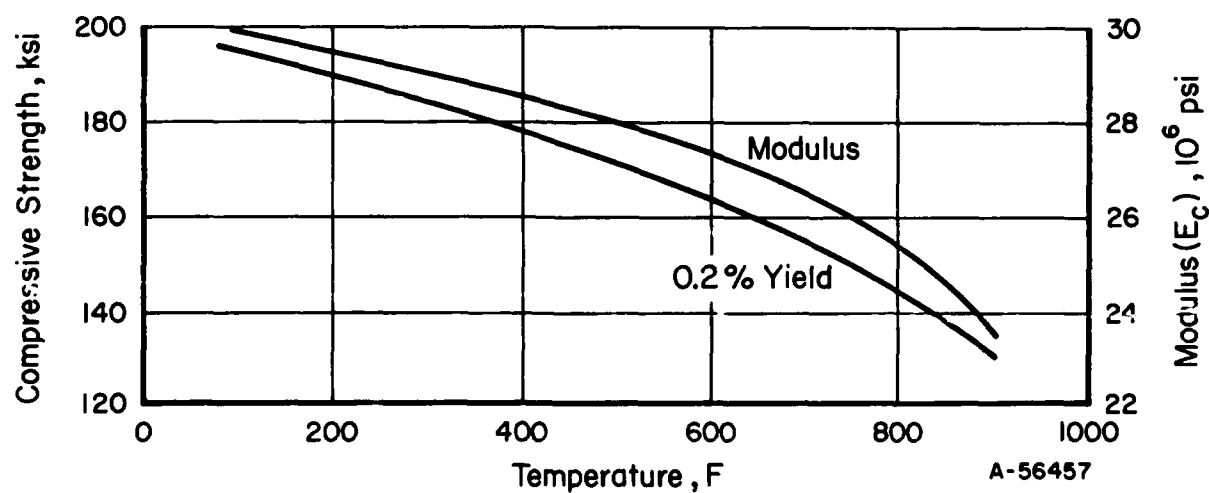


FIGURE 2. EFFECT OF TEMPERATURE ON THE COMPRESSION PROPERTIES OF HP 9-4-25 FORGINGS

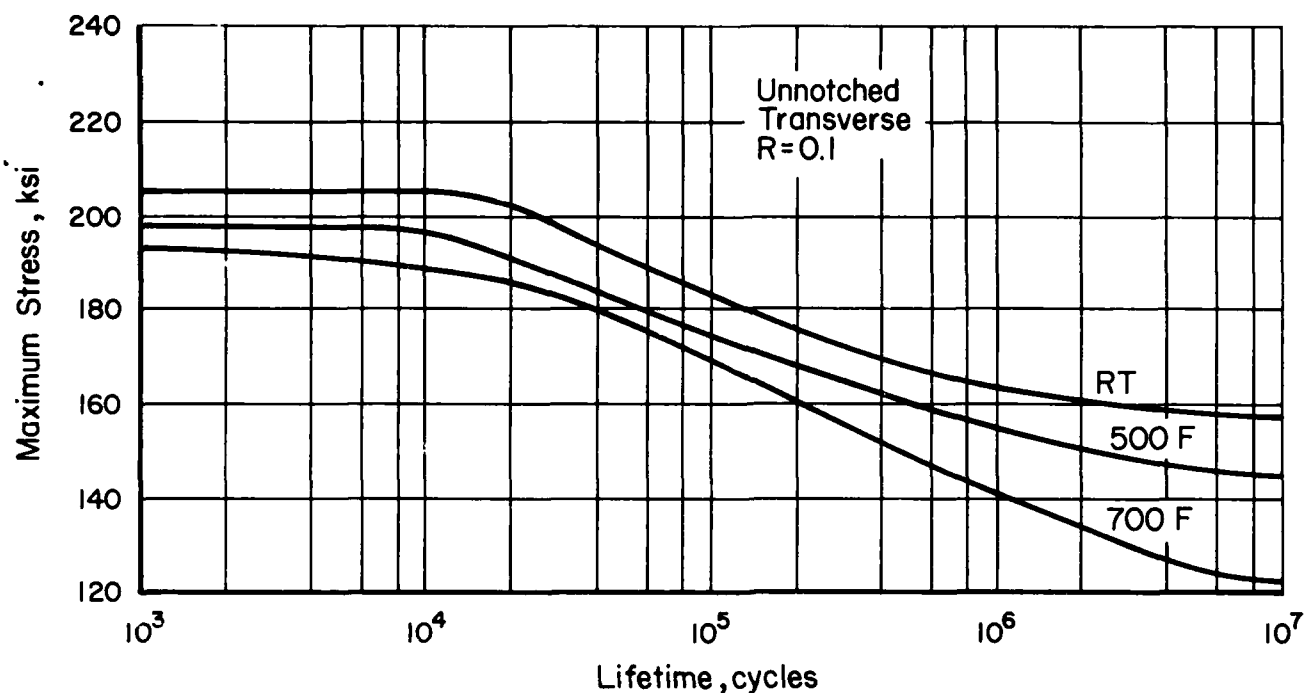
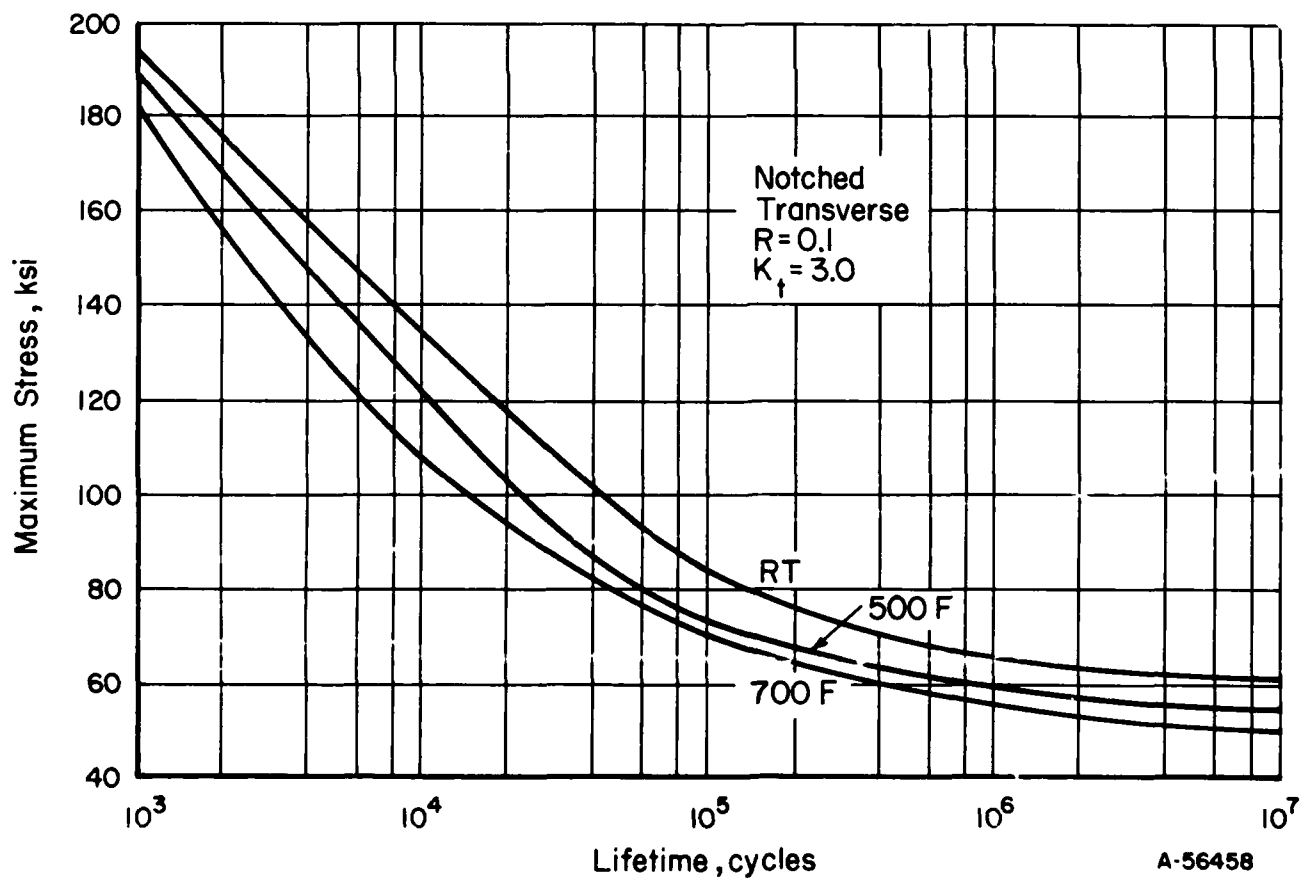


FIGURE 3. AXIAL LOAD FATIGUE RESULTS FOR HP 9-4-25 FORGINGS AT THREE TEMPERATURES



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FIGURE 4. AXIAL LOAD FATIGUE RESULTS FOR HP 9-4-25 FORGINGS AT THREE TEMPERATURES

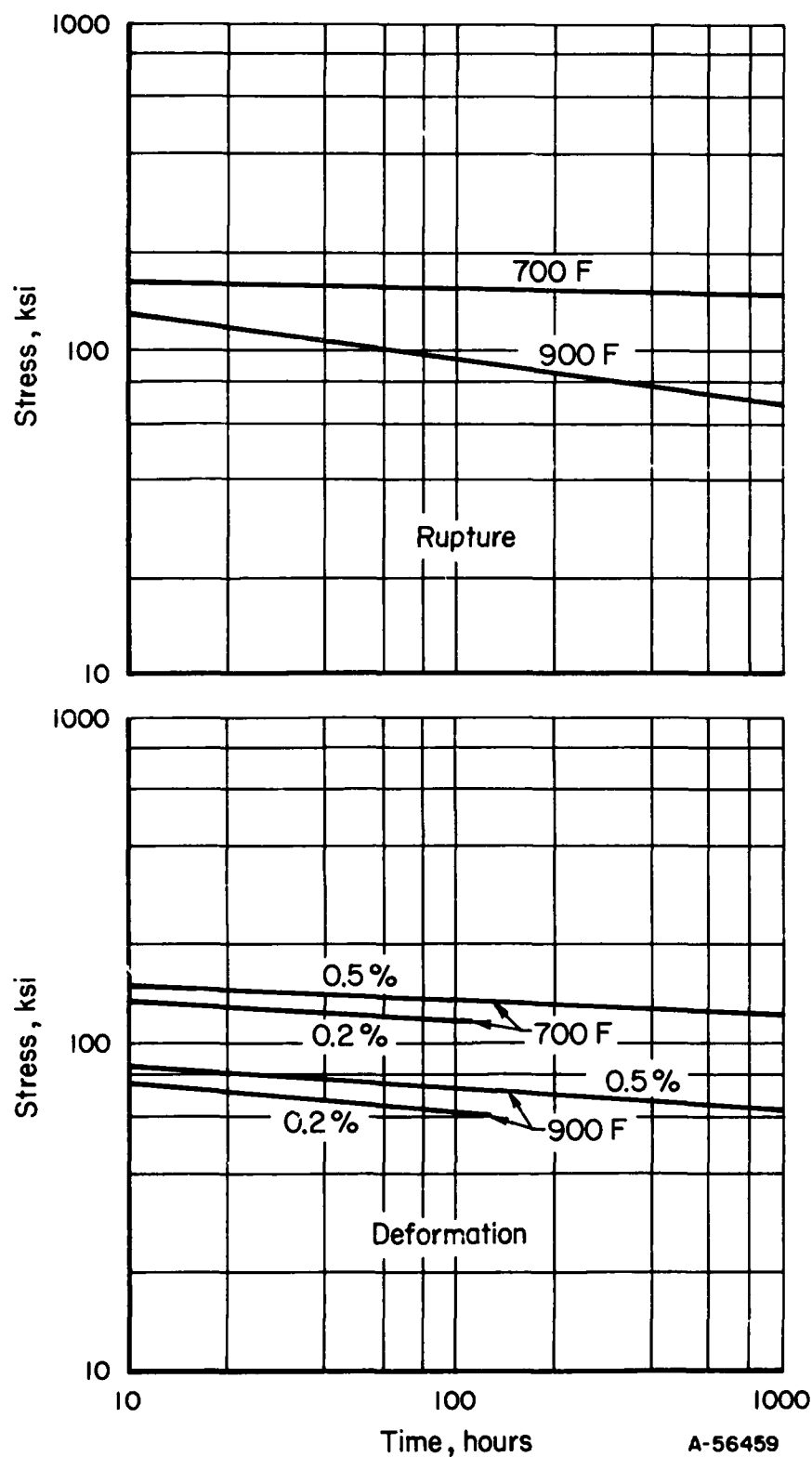


FIGURE 5. STRESS-RUPTURE AND PLASTIC DEFORMATION CURVES FOR HP 9-4-25 FORGINGS AT TWO TEMPERATURES



## REFERENCES

- (1) Pascover, J. S., and Matas, A. J., "Properties of HP 9-4-X Alloy Steels", WADC TDR 64-225 (1964).
- (2) "Preliminary Technical Data on the Republic Hi Performance Steels", Republic Steel Brochure.